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On the theory side, new complexity results were presented for various interior linear programming methods. New interior methods with polynomial complexity were described for certain quadratic programming, convex nonlinear programming, integer programming and linear complementarity problems. Strategies have also been developed for retaining polynomial convergence starting from an infeasible point. For all problem categories, properties of Newton's method and of the "central path" (the trajectory of minimizers of the logarithmic barrier function) play a key role in much of the analysis. A frequent theme is the development of "large-step" methods that do not require the iterates to follow the central path closely, yet achieve a polynomial complexity bound. Research on the anticipated complexity of certain interior methods may help to explain why the performance of these methods is substantially superior to their worst-case bounds.

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Final Report
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and the
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Second Asilomar Workshop on Progress in Mathematical Programming
February 5–7, 1990

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Since 1984, excitement about new approaches to linear programming and other optimization problems has continued unabated and shows no signs of fading. As part of this activity, the SIAM-organized workshop on "Progress in Mathematical Programming", was held at Asilomar, California, February 5–7, 1990, to bring together researchers working in a variety of fields, mostly related to interior methods.

This workshop was the fourth in a series initiated by Neal Glassman and the Office of Naval Research in 1986. The first was held in 1986 at the Naval Postgraduate School in Monterey, California; the second at Asilomar in 1987; and the third in 1988 at Bowdoin College, Maine. The most recent workshop received generous financial support from the Air Force Office of Scientific Research and the Office of Naval Research, and was sponsored by the SIAM Activity Group on Optimization. The technical organizing committee consisted of Nimrod Megiddo, IBM; Kurt Anstreicher, Yale University and CORE, Belgium; and Margaret Wright, AT&T Bell Laboratories.

Sixty-six researchers from ten countries attended the workshop. An atmosphere of intensity and friendliness was maintained throughout; participants ate all meals together, and then gathered every evening for refreshments and further discussion.

No talks were designated as "invited". Rather, participants who wished to give pre-scheduled talks were asked to submit abstracts in advance, and a subset of these were selected by the organizing committee. The program was deliberately informal, including talks scheduled in advance, others organized on site, and substantial time reserved for discussion. The broad range of topics covered by the talks shows the vitality of the field in both theory and practice. The talks were widely agreed to achieve a remarkably and uniformly high standard of technical content, interest and presentation.

On the theory side, new complexity results were presented for various interior linear programming methods. New interior methods with polynomial complexity were described for certain quadratic programming, convex nonlinear programming, integer programming and linear complementarity problems. Strategies have also been developed for retaining polynomial convergence starting from an infeasible point. For all problem categories, properties of Newton's method and of the "central path" (the trajectory of minimizers of the logarithmic barrier function) play a key role in much of the analysis. A frequent theme is the development of "large-step" methods that do not require the iterates to follow the central path closely, yet achieve a polynomial complexity bound. Research on the anticipated complexity of certain interior methods may help to explain why the performance of these methods is substantially superior to their worst-case bounds.

In a more practical vein, the latest computational achievements were described for several interior methods, including a primal-dual algorithm based on applying Newton's method to solve the nonlinear equations associated with the trajectory of the logarithmic barrier function. Other speakers discussed issues of sparse linear algebra and numerical analysis that arise in solving the special linear systems associated with interior methods, such as ordering strategies for the Cholesky factorization and preconditioning techniques.

"Classical" topics received attention as well—particularly stochastic programming and piecewise linear programming. Connections between interior methods and analysis of quadratic and superlinear rates of convergence have been determined that not only shed light on observed computational behavior, but also indicate how to choose algorithmic parameters to achieve the best convergence rates.

Two directions in applications were described at the workshop: linear programming-based techniques have been used with great success to classify malignant and benign tumors in breast tissue; and the Air Force Military Airlift Command has already applied interior methods to solve linear programs with several hundred thousand variables, and hopes eventually to reach millions of variables.

Although certain themes recurred throughout the meeting, it is impossible to identify a single trend in work on interior methods. Researchers are increasingly consolidating classical and new work into a unified body of knowledge. Results and insights are still being produced at a rapid rate, with no indication that the pace is slowing down. Future work seems certain to apply interior methods to wider and wider classes of combinatorial and general nonlinear problems.

List of Speakers

Second Asilomar Workshop on Progress in Mathematical Programming

February 5–7, 1990

Kurt Anstreicher, On the performance of Karmarkar's algorithm over a sequence of iterations

Paul Boggs, Optimal 3-D methods

George Dantzig, Progress in stochastic programming

Dick den Hertog, A potential reduction method for smooth convex programming

Curtis Eaves, Arrangements of linear programs with spheres and hemispheres of objective vectors

Robert Fourer, Algorithmic implications of piecewise-linearity in linear programming applications

Robert Freund, Potential reduction algorithms for solving a linear program from an infeasible "warm start"

Clovis Gonzaga, Large dual updates in potential reduction algorithms for linear programming

Dorit Hochbaum, The complexity of integer nonlinear optimization

Florian Jarre, A homotopy method for convex programming

Bahman Kalantari, A generalized Gordon theorem for homogeneous functions and its implications

Leonid Khachian, Polynomial-time algorithms for doubly stochastic diagonal scaling of positive matrices

Masakazu Kojima, A unified approach to interior point algorithms for linear complementarity problems

Kenneth Kortanek, Computation in the collapse state in limit analysis using the LP primal affine scaling algorithm

Irvin Lustig, Formulating stochastic programs for interior point methods

Olvi Mangasarian, Pattern separation via linear programming: theory and an application to breast cytology diagnosis

Nimrod Megiddo, Parallel complexity of linear programming

Shinji Mizuno, An $O(n^3L)$ long step path following algorithm for a linear complementarity problem; a rank-one updating algorithm for linear programming

Sanjay Mehrotra, On the implementation of primal-dual predictor-corrector algorithms

Walter Murray, Will the real primal-dual algorithm please stand up?

Larry Nazareth, Gradient-based algorithms for linear programming derived from quadratic and conic models

James Renegar, Towards a very general theory of condition numbers

Kees Roos, Polynomial-time long-step algorithms based on the use of the logarithmic barrier penalty function

Ben Rosen, Efficient computation of convex hulls in R^d

Michael Saunders, Preconditioning KKT systems (not AD^2A^T)

David Shanno, Current state of a primal-dual interior code

György Sonnevend, On the complexity of following the central path of linear programs by linear extrapolation

Richard Tapia, On the superlinear and quadratic convergence of primal-dual interior point linear programming algorithms

Michael Todd, Anticipated behavior of path-following algorithms for linear programming

Kaoru Tone, An $O(\sqrt{n}\,L)$ iteration large-step logarithmic barrier function algorithm for linear programming

Pravin Vaidya, A new algorithm for minimizing convex functions over convex sets

Robert Vanderbei, Implementation issues for interior-point methods

Yinyu Ye, Anticipated behavior of interior point algorithms for linear programming

Dong Xiao, On the complexity of the projective interior point method

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February 4–7, 1990

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